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West Europe Report

SCIENCE AND TECHNOLOGY

No. 100

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FRANCE: ADVANCED INTEGRATED-CIRCUIT-MANUFACTURING EQUIPMENT

Paris L'USINE NOUVELLE in French 21 Jan 82 pp 69-71

[Article by Claude Amalric: "Integrated Circuits: Herewith the French Machines"]

[Text] Two steppers, a plasma etcher, a high-speed masker, diffusion kilns, and soon an ion implanter. The French integrated-circuit-manufacturing industry is now born. And straightaway, it seems to be performing very well.

In 3 years, an industry has come into being in France: That of the highly specialized machines that are indispensable to the manufacture of integrated circuits. Without them, a French electronics industry is out of the question. For, to be competitive, we must be able to offer the most advanced technology, with circuits manufactured at high speed and without too many rejects. The makers of these machines, until now principally the Americans and the Japanese, have been reserving their first machines to their own national manufacturers, claiming as the reason, which is partly justified, the need to perfect their machines in their home markets. The result is that the machine does not become available to other clients until the world markets have been cornered by the first to whom they have been made available... Hence the importance of developing such an industry, which was well provided for in the previous Administration's "components plan" and which, according to all statements of intent, will be heavily backed by the plan that is to follow.

What has taken place so far represents the initial tangible effects of this policy at this time. At the end of November of last year, CIT-ALCATEL [International Telephone Company - Alsatian Company for Atomic, Telecommunications and Electronics Construction] unveiled at its Annecy plant its GIR 200, an RIE [Reactive-Ion Etching] machine capable of etching image traces 1 micron in width under normal production conditions. It was time: In 1981, the standard went down to less than 2 microns for the highest-density circuits. By the end of 1982, it will be down around 1.5 microns. "The investment in machines, which absorbed 50 percent of the credits allocated to the 1978 components plan, will have to be renewed entirely this year. For, this equipment has a useful life of 3 years," says Jean-Jacques Bessot, head of the thin-layer machines division of CIT-ALCATEL. The cost

of the GIR 200: 800,000 francs. "That is 20 percent less than the American competition's cost." This is fortunate, in that, "To sell abroad, it is first necessary to have clients in the United States. That is the reference point." MHS [MATRA [Mechanics, Aviation and Traction Company]] Harris, however, will be the first purchaser of this equipment, which was built to that company's specifications. The second buyer will be EFCIS [expansion unknown]-Thomson: Another French firm.

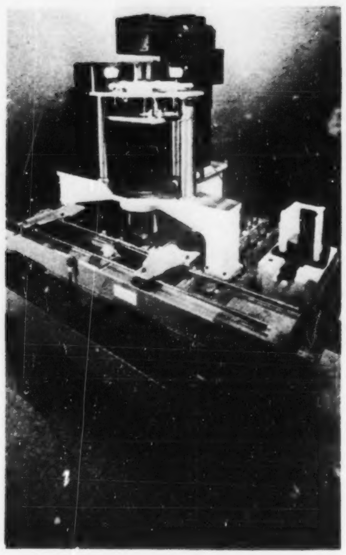
The etching of lines 1 micron thick is very difficult. Indispensable to it is the mastery of vacuum techniques, of materials resistant to corrosion by manipulated gases, of accessories such as electromagnetic sluices, flowmeters, etc. This is why the AEC's [Atomic Energy Commission] LETI [Laboratory of Electronics and Data Processing Technologies], which had released the basic study, wanted to have CIT-ALCATEL, which specializes in all these domains, actualize the industrialization phase. The dry-etching technique used in the GIR 200 is a state-of-the-art technique that is not yet in widespread use in the production sector, which still strongly favors "dip and wash" acid-etching methods comparable to those used for integrated circuits. It is one of the extremely few processes, however, suited to the etching of sub-micron details. Therein lies its attraction and that of the ALCATEL machine.

Another type of machine, mastery of which is considered a prime requisite, is the wafer-stepping photoreducer ["stepper"]--a name that designates its function: Starting with a mask to the scale of 5 or 10 of a circuit to be reproduced--a connecting layer, for example--the machine mates one after the other the etched layers containing the integrated-circuit chip patterns pertaining to a single silicon wafer. A 4-inch (100 mm in diameter) wafer thus contains 81 chips. A mere statement of the task to be accomplished is in effect a statement of the problems to be resolved: The image resolution involved requires a very special wide-angle optical process capable of covering more than 1 square centimeter of image without distortion. This is another fortunate circumstance for French industrialists seeking to produce steppers: One of the--if not the--world's most highly qualified specialists in this field is CERCO [expansion unknown], which for a long time received backing from the DGRST [General Delegation for Scientific and Technical Research] in this research, without immediate fallout at the time. But the principal difficulty of a stepper is the X-Y displacement of the table that holds the wafer. For optimal production output, this displacement along two axes must be the fastest possible despite the final precision requirement: 0.1 micron! It is the manner of achieving this that most differentiates, at this time, the machines of this type.

Composite Materials to Improve Displacement Times

CAMECA [expansion unknown], a Thomson-CSF [General Radio Company] subsidiary, is in the process of putting the finishing touches on a stepper the prototype of which is to be delivered to EFCIS [expansion unknown] in April. Gerard Coussot, CAMECA's director of sales, is proud of his product: "The approach to the alignment problem is original. Instead of having positioning marks that take silicon space away from the circuits, we have placed them between the chips, over the future sawing notches." The result is a space gain on the wafer. Moreover, the

Plasma etchers are still rare. The future is theirs. CIT-ALCATEL's GIR 200 is among the best-performing.



Steppers are among the most difficult machines to build. Euromask, a newcomer, appears to have achieved a masterpiece with its Eurostep 2000.

fine adjustment of the positioning is obtained by means of a laser interferometer. The disadvantage is that the required precision is assured only by processing in a controlled atmosphere surrounded by a special enclosure. Two competitors--Philips and CGA [General Automation Company]--also use interferometry. To overcome the constraints imposed by the system's sensitivity to environmental conditions and by its low thermal inertia, the American company Optimetrix has deposited a metallic grid on a thick glass plate. This grid, fixed under the X-Y table, is displaced by the latter. A fixed microscope reads the reticle, which moves past it.

"It is a good system," says Paul Tigreat, a longtine user of such equipment and now director general of Euromask, a subsidiary of MATRA (but not of MHS) for such machines, "but we do even better!" Paul Tigreat is favored by a third "fortunate circumstance": Even more so than was the case with the CERCO lenses, Jobin-Yvon's holographic grids appeared to many scientists to have no evident usefulness when the DGRST was financing their research. The fallout is now the following: By means of a cross-hatched holographic lattice, Euromask's engineers have replaced the Optimetrix grid, preserving at the same time the measuring system's insensitivity to the environment--hence, no controlled atmosphere.

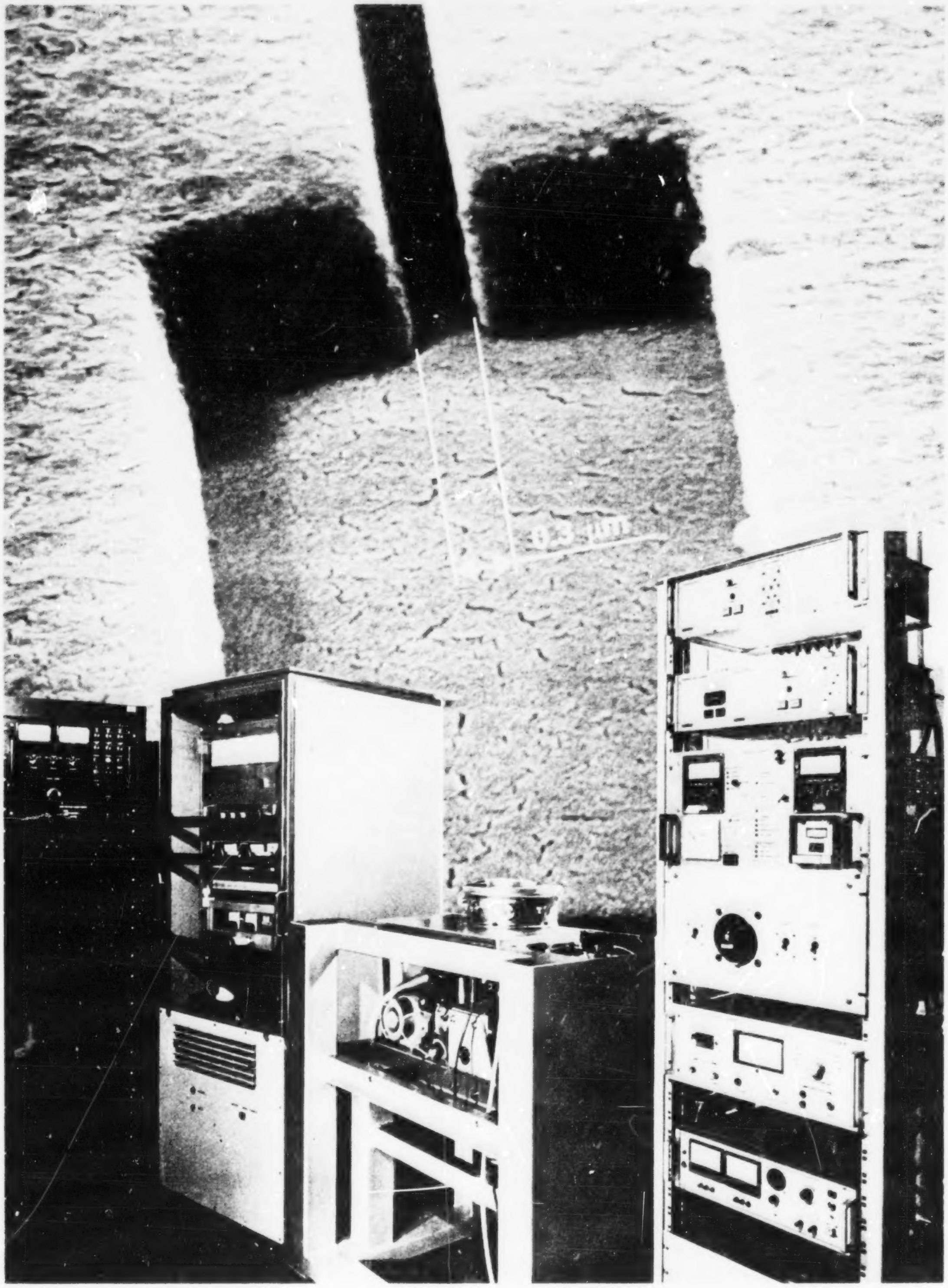
To capitalize further on his advantage, Paul Tigreat has called upon the past experience of his deputy, the former director of methods for MATRA Automobiles. "Besides an entirely fresh viewpoint, he has brought us some ideas the experts do not think of. For example, to shorten the displacement time of the table, which nevertheless must be very rigid, he suggested the use of composite materials. Excellent!" Thanks to this solution, the Eurostep 2000 table is expected to be able to take a 1-cm step in 200 milliseconds this year. The current time of 250 milliseconds represents the best performance of its competitors.

"We are also working on an exposure time of 60 milliseconds versus the current average of 200 milliseconds for our competitors." This gain has resulted from the position in which Euromask found itself of having to build its own illuminator. "Initially, I wanted to buy this subassembly from a well-known Los Angeles supplier. The deeply discouraging terms offered us by the supplier, as to price as well as delivery, conveyed a very clear message: No sales to foreigners. I clearly understood then the name of the game; and within the delivery time that had been quoted us, we studied and built our own illuminator..." Something to think about.

The Euromask stepper will also be delivered to its first clients (MHS and the CNET [National Center for Telecommunications Studies] at Meylan) this spring. The price of a machine is of the order of 3-4 million francs, and each production line of an integrated-circuit manufacturer, to be properly equipped, requires four of these machines.

An Absolute Record: Ten Masks Per Hour

The masks themselves are produced by another machine called a "high-speed masker" in view of its rate of output. Indeed, for this delicate operation, 30 minutes



New machines for the production of integrated circuits must have a precision of the order of 1 micron. Research on the next generation, however, requires working in the submicron range. Hence this X-ray machine developed by CAMECA.

per mask is not too long. But CAMECA has also announced a winner with its electron-beam masker, which is truly a high-speed one, in that it can produce 10 masks (1-micron resolution) per hour! An absolute record. The sole French firm specializing in this equipment, CAMECA will deliver its first FTPG [expansion unknown] at the end of January to the LETI in Grenoble. Another one will be sold in September 1982.

CAMECA, which a few years ago failed to come up to expectations, has suddenly awakened. In addition to the two above-indicated machines, CAMECA is now bringing out an experimental apparatus designed for laboratories. The XPWS 301 is an X-ray stepper capable of etching lines 0.1 microns thick in the photoresist of a wafer. This involves a positioning held to within 0.02 microns approximately... "Therein lies the entire difficulty with this equipment," says Gerard Cussot, "which is why we prefer to sell only the table and its operating mechanism."

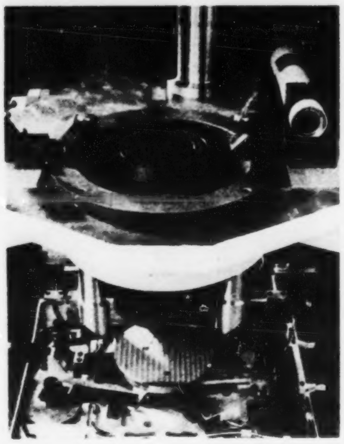
Flanking the subsidiaries of large groups, such as CAMECA and Euromask, very small enterprises are fitting themselves into the market niche for integrated-circuit machines. This is the case with Seirat, at Louverne, near Laval. Formed 18 months ago, this enterprise custom-builds automatic test equipment to specifications for multilayered hybrid circuits, a domain in full evolution that has been neglected to date by such as GENRAD [expansion unknown] and Teradyne. But above all, Seirat has a contract with the DIELI [Directorate of the Electronics and Data Processing Industries] and the DAII [Directorate of Industrial and International Affairs] for the study of an ion implanter, another machine that will have to be built in France. "The implanter becomes necessary when we come down to 1 micron and less," says Jean-Claude Roland, director and creator of Seirat. "Ours will be highly automated. It will moreover be able to process 13 wafers 6 inches (150 mm) in diameter at a time." Automatic loading-unloading, routines on floppy disk to avoid operator error, low heating of boards to less than 150 degrees C (versus 500 degrees C with non-automated implanters), thus eliminating processing stages, are the main features of this equipment, which should be ready by the end of this year and marketed in 1983. Apparently, Serait will then be the sole European maker of ion implanters, with a more advanced machine than any known to be forthcoming. Having started up with two persons, Jean-Claude Roland plans to employ 80 persons by 1985.

At Montpellier, Semy Engineering builds diffusion kilns. Although less critical than a stepper, these kilns are no less indispensable to the production of integrated circuits. Here again, the enterprise is a recent one: Its creator, Yvon Pellegrin, formed it in 1980 with a stack of orders already in hand that assured its future. For, like Paul Tigreat, Jean-Claude Roland and all those who are entering this niche, Yvon Pellegrin has a long past as a user of the machines he builds.

The year 1982 will thus mark the real takeoff of this new industry. A good base for the new components plan being drawn up.

One-Tenth of a Micron Without Constraints

Laser interferometry is known to those who must measure very small displacements or where it becomes necessary to know with a high degree of precision the position attained. Since laser interferometry has been the sole means of achieving the required precision, its users have accepted its constraints. Among its principal constraints are the following: The variation in laser wavelength with changes in environmental parameters imposes the need for controlling the atmosphere in which the equipment operates. Furthermore, the possible increment cannot be other than a submultiple of the laser wavelength, and not a metric unit. All these constraints have been eliminated by Euromask, which has replaced the laser interferometer with a holographic lattice on the X-Y table of its stepper. The precision remains the same: 0.1 micron over a displacement of 15 cm. And its equipment features a set of characteristics that can offer a solution to industrialists not concerned with microelectronics. "We are prepared to discuss their problems with those who might be interested," says the president of Euromask, Paul Tigreat, who thought of this solution himelf.



Use of a holographic lattice has endowed the table of this stepper with a set of astounding characteristics.

9238
CSO: 3102/158

FRANCE PLANS LONG-TERM, SYSTEMATIC SOLAR RESEARCH

Frankfurt/Main FRANKFURTER ZEITUNG/BLICK DURCH DIE WIRTSCHAFT in German
5 Feb 82 p 7

[Text] In West Germany, the French nuclear energy program is well known; it is being completed without interruption. This is being done with a research expenditure about 30 percent smaller than in West Germany. It is forgotten that France also provides considerable government funds for nonnuclear energy. The French national research expenditures for 1982 compare to 1981 as follows:

National Solar Energy Funds for 1982 and 1981 (in millions of Francs)

Year	1981	1982
Total	209.3	309.5
Direct use	72.0	81.0
Biomass	50.0	80.0
Diffusion	31.0	70.0
International projects	20.0	24.6
Information	10.0	15.0
Infrastructure	26.3	38.9

In 1982 the government expenditures for research in France will amount to about 120 million DM and have a nominal 48 percent increase over 1981. Even under consideration of an inflation rate of 15 percent, this means a drastic increase in government aid. It is notable that the emphasis of support in research and development is on biomass utilization. This is completely in contrast to West Germany. The emphasis in the French national solar energy research program is notably different from the comparable German solar energy program. This cannot be explained by the difference in sunshine, but from a different conception on the use of solar energy prevailing in the French Government. This difference in the structure of the research expenditure is also not a result of the new French Government, but was in place even before.

The German concept of solar energy research aid--as conceived by the Federal Ministry for Research and Technology--is directed to research projects which promise quick success. There can be no talk of a long-term-oriented solar energy research in the Federal Ministry for Research and Technology. Quite the contrary, in France efforts are underway on a long-term research with government support.

9280
CSO: 3102/153

LARGE-SCALE PRODUCTION OF SYNTHESIS GAS BY 1984

Frankfurt/Main FRANKFURTER RUNDSCHAU in German 20 Feb 82 p 14

[Article by Dietrich Zimmermann: "Lignite Gas Soon to Return"]

[Text] Development has progressed to the point that in just under 3 years coal gas will again be produced in a large-scale facility in the FRG. In October 1981, the construction of a large-scale demonstration facility was begun on the premises of the Rheinische Braunkohlenwerke briquet factory in Huerth-Berrenrath, a small town on the outskirts of Cologne. The first of four production lines will start operating in 1984, generating 300 million m^3 of synthesis gas each year from lignite for producing methanol. The other three lines will be ready for operation in 1988 if the first installation works as planned.

That this involves more than just a demonstration project is evidenced by the amount of the investment. The first production complex alone will cost about DM 200 million, a sum which must be raised by the firm itself since the Federal Ministry for Research and Technology (BMFT) has already assumed 65 percent of the cost of a pilot plant. Such extensive financial involvement indicates that profits are expected from the facility. Actually, if the gasification facility were put into service today, it would operate very close to the break-even point. According to the unanimous conviction of the experts, the threshold of profitability will surely be crossed in just a few years.

This conviction appears at first glance to contradict the prevailing opinion that at the earliest it will be 10 years before the products from coal conversion will be competitive with the products derived from petroleum and natural gas. However, the contradiction is easy to resolve: In the facility now under construction near Cologne, the material which will be processed is lignite, and compared to hard coal, which is difficult to mine in the FRG, it is so cheap that, for example, electricity generated from it can even undersell electricity from nuclear power plants.

However, it is not just for economic reasons that lignite is especially well suited for gasification. Since it is from a considerably more recent geological period and is more wood-like, its porportions of easily

gasifiable constituents is significantly greater. And these substances, which are released by simple heating, are consequently very reactive.

To generate synthesis gas from coal, the latter must be heated to 900 to 1,000 degrees C, and then flushed with a gasifying agent, a mixture of steam and air or pure oxygen. The carbon combines with the oxygen to form carbon monoxide (CO) which is one component of synthesis gas. The other component is pure hydrogen (H_2). It is generated as the steam decomposes at high temperature into its constituents, hydrogen and oxygen. The oxygen is used to form carbon monoxide and the hydrogen remains free.

The term "synthesis gas" is derived, by the way, from its intended purpose: It is intended for the synthesis of organic compounds. Since for a particular synthesis a definite ratio of carbon monoxide and hydrogen is required, an attempt must be made to come as close as possible to this ratio in the gasifying process. The synthesis gas generated in Cologne is to be transported via pipelines to nearby Wesseling where it will be converted into methanol; thus, part of the tests carried out in the three-year-old pilot plant serve to determine the operating conditions required to generate the optimal gas mixture for this methanol synthesis.

With a height of 32 m, even the pilot facility has impressive dimensions. The cylindrical reaction vessel suspended in a support frame and surrounded by countless pipes and tanks has an outside diameter of 1.5 m and a height of 10 m. In it about 2,200 m^3 of synthesis gas can be generated each hour from 4 t of powdered lignite. The coal dust is carried by carbon dioxide gas to the uppermost scaffold platform from which it falls through several sluice-like vessels in which it is brought to a pressure of 10 bar, the working pressure in the reaction vessel, a fluidized-bed reactor. In the reactor the dust gasifies as it mixes with the gasification medium. The mixing is accomplished by turbulent agitation as the gasifying agent is injected into the vessel under pressure. Part of the coal, about 30 percent, must be burned in the process to maintain the temperature, about 900 degrees C, required for gasification.

The future large-scale production installation will also work according to this modified high-temperature Winkler process. The lignite dust, 280 t per hour at peak capacity, will come from the briquet factory. The four brick-lined fluidized-bed reactors will have a length of about 15 m and an outer diameter of about 4 m; the height of the support frame will grow to 65 to 70 m. Then the resulting synthesis gas will pass through one more conversion unit in which the ratio of carbon monoxide to hydrogen is adjusted to correspond to the exact requirements for methanol synthesis.

At the Union Kraftstoff company in Wesseling, the synthesis gas will be pumped into a pipeline complex which connects with the various gas users. This pipeline is presently supplied by an oil gasification unit. If all goes according to plan, lignite gas, once converted, will replace about 2 million tons of crude oil per year. A heavy oil is left behind by the gasification process. Construction has been planned for a vacuum

distillation facility to convert this residue into such sought-after products as gasoline and light oil.

It is interesting in this connection that synthesis gas was produced until 1964 by the Rheinische Braunkohlenwerke, using the Winkler process. At that time the price of oil dropped to a level where even lignite lost its ability to compete. In the meantime, just short of 20 years, conditions have once more changed in a fundamental way. Lignite can again compete, but of course it is no secret that gas production by the Winkler process was more than doubled by process improvements.

But the firm's development work has not been limited to coal gas production. The construction of a pilot plant for producing methane, or--in more common terms--natural gas, from lignite is in the offing, and planned for 1986 is a pilot plant for the liquefaction of coal--facilities which, like similar projects for conversion of hard coal, are subsidized by the federal government. In all of this, the problem of environmental pollution is in no way neglected. The licensing procedure for the large-scale synthesis-gas facility was able to be completed according to the rigorous regulations of the emission control law. The flue gas emission will be increased only slightly compared to the present situation at the location, and dust emission will be distinctly decreased due to reduced briquet production.

9160
CSO: 3102/177

BRIEFS

FRG, BRAZIL COAL TECHNOLOGY TRANSFER--Within the frame of partnership between the South Brazilian University's Universidade Federal de Santa Catarina in Florianopolis (UFSC) and the Rhine-Westfalia Technical University in Aachen (RWTH), a joint research project on coal technology is being established at the Brazilian University. Since August 1981, nine Aachen scientists, organized by the Bureau for Technology Transfer, have been preparing members of the faculty of the partner university in lecture series for the new research department. A seminar on coal technology was held for about 150 persons from the Brazilian coal industry, the ministry, and scientific facilities. A request of the UFSC to the cognizant ministries requests support of the Department of Coal Technology in the years 1983 to 1985. The request is for Brazilian funds and for funds from the Federal Ministry for Scientific Cooperation in Bonn. The successfully concluded preparation program is a good indicator of cooperation in the request. [Text] [Duesseldorf VDI NACHTRICHTEN in German 15 Jan 82 p 1] 9280

SYNTHETIC NATURAL GAS PLANT--The two companies, Didier Engineering GmbH of Essen and Thyssengas GmbH of Duisburg have undertaken a joint project to produce substitute natural gas from gasification gases by one-step, combined conversion and methanization in a catalytic fluidized bed. For practical testing of this method (called Comflux), a pilot plant is now in operation on the grounds of Ruhrchemie in Oberhausen-Holten; it is planned to be in operation until the end of 1983. This facility is designed to produce about 2,500 m^3 of methane per hour. A mixture of oil or coal-gasification gases from neighboring gasification plants and hydrogen as the additive gas can be used as synthesis gas. [Text] [Frankfurt/Main FRANKFURTER ZEITUNG/BLICK DURCH DIE WIRTSCHAFT in German 11 Feb 82 p 7] 9280

CSO: 3102/153

USE OF HIGH PERFORMANCE COMPOSITES INCREASING IN INDUSTRY

Paris L'USINE NOUVELLE in French 25 Feb 82 pp 72-78

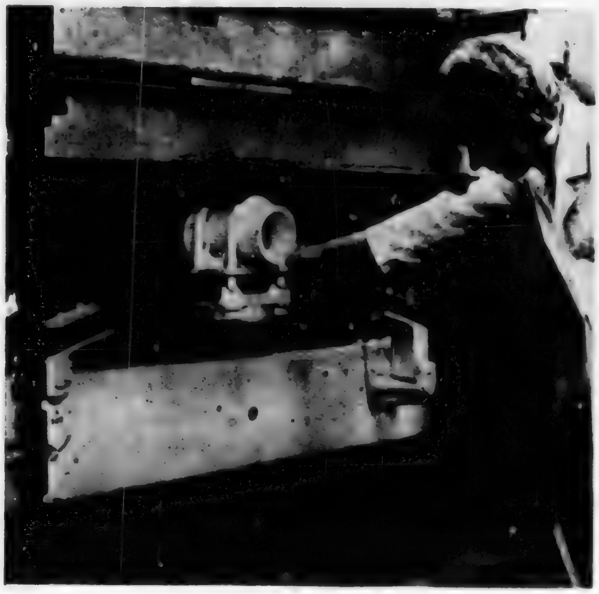
[Article by Pierre Laperrousaz. "Small and Medium-Sized Industries: Think Composites!"]

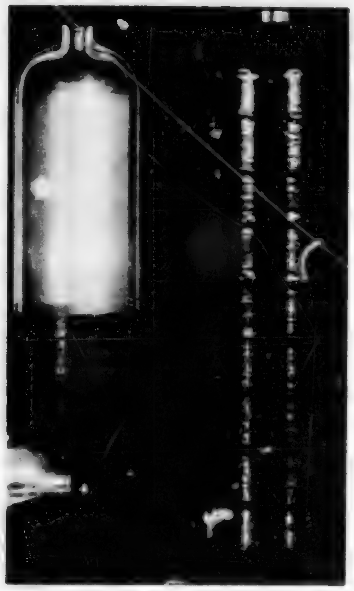
[Text] High performance (HP) composite materials have made decisive inroads in aeronautics. But their mechanical possibilities are barely beginning to be explored. Their success in this area will depend on the capability of designers to "think composites " the efficiency of technology transfers, the mechanization of processes, and of course, their cost.

In its Basel pilot plant, Ciba-Geigy manufactures and tests driveshafts that weigh 3-4 kg, compared to the 10-12 kg of conventional steel shafts. These parts, some of which have already travelled many kilometers, are made of composites based on epoxy resins reinforced with various fibers: glass, carbon, and aramid. At Snias in Bordeaux, water and mud injection pipes made of glass-epoxy or carbon-epoxy composites, and used for deep underwater oil exploitation, are three to four times lighter than their steel equivalents. At Rubery-Owen in Great Britain, springs with blades made of a glass-carbon composite weigh 25 kg, compared to 90 kg for steel. At General Motors in Detroit, a truck chassis U-beam made of carbon-aramid-epoxy, is 6 meters long and weighs only 46 kg (62 percent less than a metal beam).

These few international examples are as many variations on a theme: the replacement of a metal with a composite which offers equivalent performance with a much lower weight. They take advantage of the essential characteristics of HP composites: exceptionally high strength and specific modulus, combined with great fatigue resistance. As a simple order of magnitude, an epoxy resin composite with a 60 percent by volume content of high modulus carbon fibers, is for equal weight, five times stronger and more rigid in the stiffening direction than a steel weakly alloyed with nickel-chromium. A composite with a base of high strength glass fibers is as rigid and five times stronger than the equivalent steel.

Many more examples of weight reduction through the use of composites are available, even if not all of them have reached the industrial stage. MBB in Germany, has built 25-meter long windmill blades out of glass-carbon-epoxy. In France, the Composit HP company in Salaunes (Gironde), is getting ready to market before the end of this year, compressed gas bottles consisting of a light alloy internal shell, reinforced with an outer winding of glass R-epoxy or aramid-epoxy. The performance





[Left] Flection tests on a truck spring at Rubery Owen (Great Britain). It weighs 25 kg, compared to 90 kg for steel.
[Right] Compressed gas bottle (300 bars) manufactured by Composite HP.

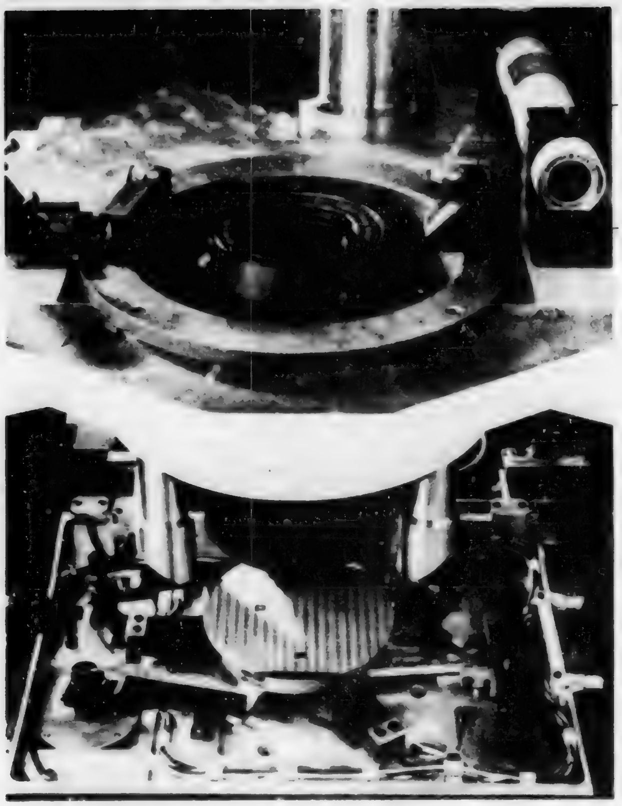
factor (volume of gas transported/weight of bottle) is four times better than that of steel. Such bottles will be used in respiratory equipment, but in the United States they are expected to serve as gaseous-fuel tanks for vehicles. There are even applications which would have been inconceivable without HP composites. One example is the case of flywheels for energy storage: steel would shatter at the speed at which they spin (up to 60 000 rpm).

However, weight reduction, whose practicality is obvious in transportation applications, is not always the main reason, or at least not the immediate one, for selecting composites.

"We have been using composites for the shuttles of some of our looms for seven or eight years," said M. Deborde, of Saurer-Diererichs (Bourgoin-Jallieu). By replacing a telescoping shuttle part previously made of aluminum, with a carbon-epoxy extrusion, this company was able to increase the width of one of its loom models and speed up its rate from 250 to 350 strokes per minute. Most competitors have since followed suit, especially the German ones. SNPE, which manufactures the extrusion, supplies 25,000 of them per year.

This is an application example in a field where the low inertia of composites combined with high stiffness and dimensional stability, offers very promising development prospects for mechanical parts moving at high speed and with high precision positioning.

A perfect example is that of the X-Y table studied and built by Comelin, which will be used in a forthcoming model of an integrated circuit fabrication machine (wafer stepper) made by Euromask (Meylan). This table supports a silicon slice or wafer,

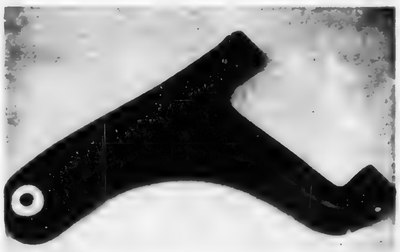


Euromask wafer stepper. The table supporting the silicon wafer is made of carbon fiber composite.

on which as many as 200 circuit patterns are printed. To move from one pattern to the next, the table moves 5-10 mm and is positioned within one-tenth of a micron. "By replacing an aluminum casting with a honeycomb composite sandwich, covered with a skin of carbon-epoxy fiber, the weight of the table was reduced from 20 to 2 kg, and the displacement rate was increased from 5 to 20 cm/s," said Paul Trigreat, director general of the company. The productivity has increased from an output of 30 wafers/hour to 50-60 wafers/hour.

One of the latest Benson drafting table models is of the same type. It includes an aramid-epoxy drum conceived and executed by Bertin. "The drum had to be of large diameter and size, while offering the lowest possible inertia so as to allow high drawing speeds. It also had to be perfectly cylindrical with no deflection at the center," we were told at Benson. The table's drawing speed is 40-80 cm/s (compared to 15-30 cm/s for a conventional tracer), and the acceleration is 4 g. In addition, the drum's greater diameter accomodates stiffer paper.

Also for the same reasons--capability for rapid and precise motion--composites are of interest for production machines such as manipulators, robots, laser cutting machines, and so on. "In order to fully utilize the laser's capabilities for rapid and precise cutting, we will have to revise the concepts of conventional machines. Composites are likely to introduce new approaches," estimates Claude Benedicte, chief executive of Laser Technique. Robot builders are also concerned with the possibilities of composites in their field. The MOC company in Chavignon (Aisne), for instance, has assembled a carbon-epoxy welding-robot head for Renault-Acma: it weighs 3 kg, compared to 6 kg for aluminum.



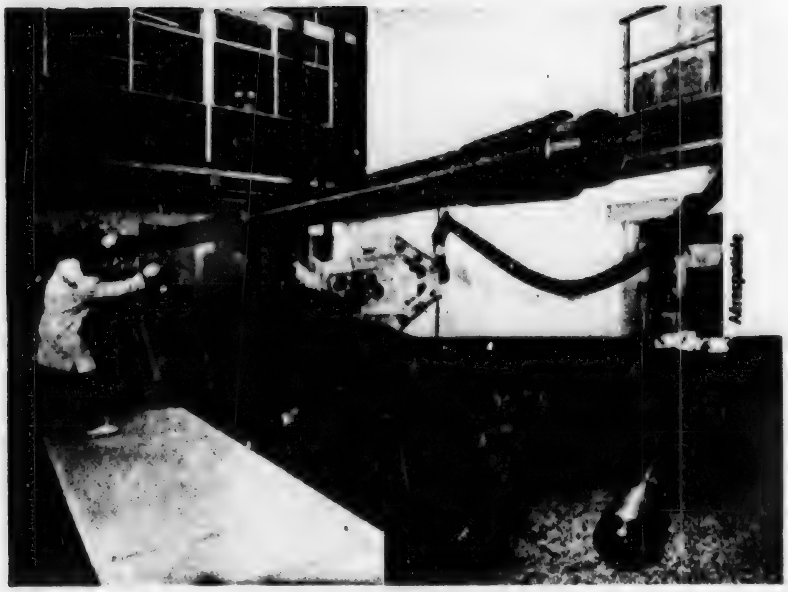
[Above] Carbon fiber extrusions manufactured at SNPE
[Top left] Robot head designed by Moc.
[Bottom left] Automobile suspension arm.

HP Composites no Longer Reserved for Advanced Industries

Secondary properties will sometimes confirm the choice of a composite. One example is the X-ray transparency of carbon-fiber reinforced resins, a property which is exploited in radiology tables (such as scanners), whose cantilevered construction must be very rigid. At other times, corrosion resistance will tilt the balance in favor of a composite, thus opening a vast field of applications in chemical engineering. Carbon or ceramic matrix materials are selected when seeking good mechanical as well as good thermal properties (resistance to thermal shock, for instance). Carbon-carbon composites are thus used in aircraft disk brakes, and land vehicles may be next (TGV, tanks, and so on). Composites reinforced with carbon-silicon carbide matrices (SEP's Cerasep) have been tested in chemical pump rotors.

Beyond their technical implications, these examples show that HP composites no longer apply solely to advanced technologies, but also to industrial parts in general. This observation matches the predictions of professional forecasters. Between 1980 and 1990, the annual growth rate for HP composites in France will be five to six times higher than that of ordinary glass fiber composites (25 percent compared to 5 percent). And according to some estimates, the industrial parts share will be far from negligible: 20 percent of the carbon fiber market in 1985, according to the most optimistic forecasts.

Trends have to be noted even more than figures, because statistical predictions concerning composites vary enormously from one source to another. One does not have to be an aircraft manufacturer or subcontractor to be interested in composites. This should already hold true today in order to avoid being surprised by a technical development which seems inevitable. Indeed, a certain degree of interest, if not anxiety, is becoming increasingly noticeable among industrialists. "There is a very



Fabrication of a carbon fiber-epoxy tube by filament winding at Snias (Bordeaux). Four times lighter than steel.

real desire for information," notes Philippe Laroche, head of the Comelin Composite Structures Division (a Matra subsidiary), which for the past year has been conducting a systematic survey of industry with a view to finding new applications. "But their misinformation is evident," he adds.

But the future of HP composites in all industrial fields will depend on the ability of designers to exploit their exceptional properties. Designers often do not think composites, or when they do, it is not with full awareness. "How often have I had to prove to an inquiring industrialist that the composite approach was not mandatory?", regretfully states Gerard Perez, of Fibre et Mica, one of whose activities is filament windings. This is a wise attitude, because composites are not to be used indiscriminately. One single case of poor performance, and their reputation is sealed as far as design specialists are concerned.

The latter are still very strongly oriented toward metals, and for them the special features of composites are fairly disconcerting. Among these features is the possibility of optimizing structures by orienting the fibers along major mechanical stresses. Another is the composites' sensitivity to stress concentration (resulting from the absence of plastic deformation), which calls for caution in the design of assemblies (a rivet or screw hole significantly weakens a part). That is why to think composites often means to also think adhesives. The transition to composites is all the more delicate since it is not limited to a simple substitution of materials. The very concept of the part must be revised, through value analysis if necessary. "It often amounts to a real upheaval for design departments, because established products must be re-evaluated," says Philippe Laroche.

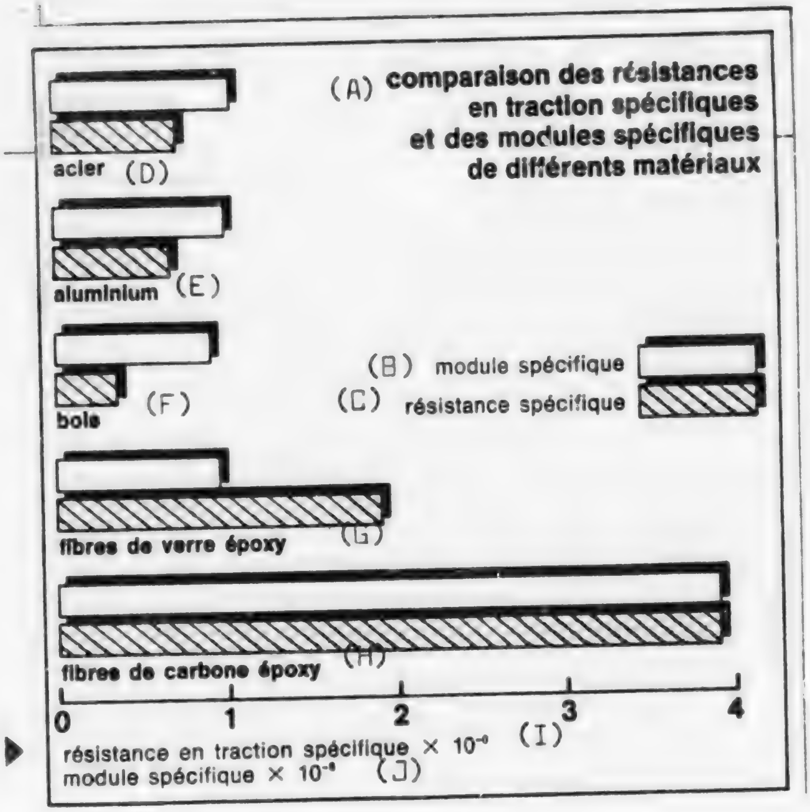
Flywheel for energy storage, made of carbon fibers. It spins at 20,000 rpm.

One Condition: Disseminate Know-How

However, these preliminaries are unavoidable if we are to reduce the additional costs generated by the use of composites, since the unit of performance (stiffness, for instance) is almost fifteen times more expensive with a carbon composite than with steel. Under these conditions, the use of composites cannot become widespread unless the total cost of their integration into assemblies can be reduced by reducing the number of parts (multifunctional parts), and by fully exploiting the possibilities for indirect weight reduction (as in the case of driveshafts which make it possible to eliminate intermediate supports); in other words by completely reexamining the product design.

In order to achieve their 1985 forecasts, enterprises must sit down at their drawing boards right now, because as they say at Ciba-Geigy, three good years are necessary between the time of the first idea and industrial manufacturing. Mr Lucas, of the Courtaulds Research Division (manufacturer of carbon fibers), even promises sweat and tears to composite pioneers. Less lyrical, Philippe Laroche confirms that the development of a composite project requires an enormous amount of time and money. He even goes as far as to ask himself whether "industrialists have the means for their wishes, and if in fact the market is sufficiently ripe." Only the industrialists in advanced sectors, such as aeronautics and aerospace, have the means and competence to design and calculate structures made of composites.

The question is to find out how this know-how will become disseminated throughout industry. Some companies, such as Snias, SEP, and Comelin, have a very open attitude in this respect. "It is in our interest to encourage the development of composites, if we want to see a lower price in fibers," says Aerospatiale. These transfers can be carried out through license sales, joint development projects, or through subsidiaries (such as Composite HP, in which Aerospatiale has a 34 percent interest).



Resin epoxy composites reinforced with carbon fibers (60 percent by volume) are four times stronger and more rigid than steel for equal weight.

Key:
- (A) Comparison of specific traction resistance and specific modulus for various materials.
- (B) Specific modulus
- (C) Specific resitance
- (D) Steel
- (E) Aluminum
- (F) Wood
- (G) Glass fiber epoxy
- (H) Carbon fiber epoxy
- (I) Specific traction resistance x 10(-6)
- (J) Specific modulus x 10(-8)

Snias, for instance, has assigned the licence for Airbus struts to two of its subcontractors, Sarma and Luchaire, and trained their personnel as well. And SEP has signed an agreement with PSA for a joint study of automobile parts (shafts, springs, suspension arms).

"In this type of involvement, our role is limited to design, prototype and pilot fabrication, and supply of know-how. But there is no question of mass production on our part," states Jean-Pierre Mermillod, head of the SEP Industrial Department. "After a few such operations, the customer's designers are familiar with composites, and can move on their own steam," he adds. As part of a Committee for the

Development of Composite Materials (Codemac) in Aquitaine, the manufacturers of the region (Snias, SEP, Dassault, SNPE, and Elf-Aquitaine), the university laboratories, and the Bordeaux Chamber of Commerce have formed an informational structure aimed at the region's small and medium-size industries (PMI) which are interested in diversifying into HP composites.

This structure would be the embryo of a future French Institute for Composite Materials. It intends to provide industrialists with information (market studies, finished product studies, new applications), training, research, and testing (parts design, materials characterization, and so on). The avowed goal is to create an industrial composites center in Aquitaine.

The development of HP composites will require the adoption of means of production, both in terms of equipment and personnel, in numbers appropriate for the technology that is adopted. The fabrication of laminates by direct impregnation, or starting with preimpregnated materials, is still a cottage industry technique, fairly easy to disseminate, and which requires only moderate investments: presses, autoclaves (10-15 bars).

Some PMI have already entered this field. MOC came to it through motorcycle competition! Its founder, Michel Moch, holds about thirty speed records with motorcycles and side-cars for which he designed and built composite frames. Today he is an industrialist working with automobiles (Formula 1 movable skirts and fins), weaponry, and aeronautics (honeycomb sandwich flooring and partitions). He has 14 employees. Another example is the Brunet company in Haubourdin. Its founder is another former champion (kayak). His accomplishments include kayaks and oars, of course, but also racing car parts (Rondeau fins). The enterprise, which now has 30 employees and a turnover of 4 million in 1981, has just moved into a new 5000 square meter building. Its goal is aeronautics subcontracting.

PMI Are Already in the Breach

"We will start with parts that are not in great demand, molded by direct impregnation, and we will progressively move to more operational structures, molded in preimpregnated form in autoclaves," says Jean-Francois Mouney, administrative director. Of course, the know-how is provided by the one who places the order: "We are not yet able to design complex parts." At MOC, an Apple II computer is used to calculate simple parts. "We are also perfecting a program which, given the mold design, should indicate a layer by layer pattern of preimpregnated materials. This would greatly simplify the shop's work," explains Michel Moch.

Filament winding is also a relatively accessible technique, with investments that are still moderate (200,000 to 800,000 francs per machine). "But while anyone can make windings today, the fabrication of sophisticated parts requires multidisciplinary knowledge about thermal and resistance properties," speculates Gerard Perez, of Fibre et Mica. Conversely, investments in carbon-carbon or all-ceramic composites are of quite another order of magnitude (at least a factor of 10): very high pressure autoclaves (1000 bars), three-dimensional looms, and so on. These can only be made by fairly large companies. But mechanical industries may quite possibly find new outlets in the machining of these materials, which relies on conventional turning and milling.

According to some estimates, the development of composites should create about 10,000 jobs by 1990, 10 percent of which will be in the higher levels (engineers and technicians). While their recruitement does not appear to create major problems (basic engineering training can be readily adapted), the same is not true for the shop personnel. "The fabrication of composites is not prestigious to a machinist," observes Georges Jube of Aerospatiale (Central Techical Offices). Indeed, no specific training for composites is presently available, and one must use retraining; Aerospatiale is even employing former cabinet makers. At Fibre et Mica, "the best results are obtained with lathe workers, but there is no general rule, and the success of retraining always depends on the individual," says Gerard Perez.

The low degree of process mechanization (as in the case of layering by piling up coats of preimpregnated or non-impregnated sheets) needs a great deal of care: some parts in aeronautics, require the hand layup of several dozen coats, each in a different orientation! For Georges Jube, training in composites must include both some notions of fundamental chemistry (what is a resin? or polymerization? and so on), and of strength of materials (relationship between the strain supported by a part, and the arrangement of fibers). Training clearly plays a large role in Codemac's program in Aquitaine: in-plant training of LEP or LET teachers, training of trainers for in-plant education, and so on).

Cost of materials, designers' ignorance, lack of trained personnel, are not the only obstacles to the development of HP composites. The specification of basic components, fibers, and especially resins, are not yet as well defined as those of metals. And the fact that most of the suppliers are foreign does not simplify matters for the French user. The need for a data bank on composites and on their behavior with time, is being strongly felt. Moreover, there also exists a need for raw materials control methods that are well defined, more industrial, and less expensive than those used in aeronautics (infrared spectrometry, chromatography, acoustical methods, holography), where control comes to represent 20 to 25 percent of the part cost!

Technique Still Limited to Short Run Production

And finally, the low mechanization of transformation processes, and the polymerization time of resins, increase fabrication costs and rule out mass production. "For the time being," says Phillipe Laroche, "the only industrial applications that we envisage concern runs of 10 to 200 parts." In the case of layering, the cutting of sheets has been mechanized with lasers or high pressure water jets. But the actual layering is still manual. Pilot models of automatic layering machines exist at aircraft manufacturers, but are justified mainly by the large surfaces with which they are concerned. The Ingersoll Milling Machine Co. in the United States, for instance, has built a numerical control machine for General Dynamics, designed to fabricate the rudder of the F 16. It lays down 15-cm wide pre-impregnated ribbons, working 15 times faster than a man. Aerospatiale is also studying such machines.

Currently, the only industrial processes are pultrusion and filament winding. Even though at first sight they are limited--the first to cross sections, the second to bodies of revolution--their possibilities are more extensive. Goldworthy Engineering (California) for instance, has perfected a curve pultrusion system which could be used to manufacture car springs or cylindrical structure members. What is

more, the same company is proposing a version of the process which would make it possible to pultrude curved objects with variable cross sections: at the end of the process, the material--still plastic--is brought into dies attached to the sides of a rotating drum. Filament winding also offers extensive possibilities. Thanks to the recent introduction of numerical control, it is used to fabricate parts with very complicated cross sections (hourglass, for instance), and even short runs.

For mass production, specialized machines reach truly industrial rates. For instance, McClean Anderson, in collaboration with Celanese, has built a machine which produces a driveshaft in one minute. And finally, it is reasonable to make parts which at first sight are not bodies of revolution (U-beams, for instance), through filament winding and splitting. Composites with thermoplastic matrices (polycarbonate, polyamide, polysulfonate) also offer an approach to more industrialized processes and higher production rates. Up to now, these materials have been used with short fibers, which is certainly not the best way to use the properties of the latter. But when reinforced with long fibers (woven, for instance) and in the form of hot-stamping plates, they could be of interest for industries in which high production rates are most important.

Forecasts for HP composites must be made with care. The only figure on which all sources agree is that the world consumption of carbon fibers is 800 to 1000 tons/year. Beyond that, the pessimists predict 5500 tons in 1985 and 22,000 tons in 1990. The most optimistic ones, the Japanese, propose 15,000 tons and 50,000 tons, respectively, for the same years. Will the production capabilities be able to keep up? If all the projects announced by carbon fiber producers see the light of day, they will exceed 3600 tons in 1982 (not including a Kureha project for 3000 tons of bottom of the line fibers). And the Japanese, still the most daring, announce 20,000 tons in 1985 (of which 10,000 tons for the bottom of the line).

At first sight, the need should thus be satisfied. But as in the case of every new technology that is starting out, we must expect ups and downs. We will probably witness alternating overproductions and shortages. The problem stands to be worsened by the automotive industry, which remains the major unknown.

A Major Unknown: The Automobile Market

All fiber makers are watching this market with a mixture of hope, because they are convinced of the advantages of their materials, and of impatience with the inertia of this sector. "At least 25 items in cars could be made of composites, with improved technical performances and weight reductions," says Jean-Pierre Gugerli, of Union Carbide (Geneva). To-date, the best prospect is a driveshaft made of glass-carbon-epoxy composite. But no manufacturer has yet made the decision to market it, to the great disappointment of materials producers: "I am waiting impatiently for one of the manufacturers to make that decision," says Mr Gugerli. "We don't care if he is Japanese, or even if he uses the fibers of our competitors! The impact of the car market can quickly turn the capability-consumption equilibrium around, and influence prices." In the downward direction, we hope.

The fact is that these high performance fibers are still very expensive: 300 francs/kg for the cheapest carbon fibers, 100 to 150 francs for aramid, and 100 francs for high-strength glass. Production capacity increases, supported by an opportunity market such as the automobile, should theoretically cause a drop in

carbon fiber prices, although certainly not to as great an extent as in the past (their 1980 price is one-sixth of what it was in 1970!). However, tar based fibers, less sensitive to energy costs, should experience the largest price reductions. The less important aeronautics market will also guide the demand toward other products, particularly rovings, whose number of filaments is higher (15,000-30,000), and whose fabrication cost is lower. But this will entail a change in transformation processes.

Another important question for French users is dependence on foreign markets. This dependence is total for aramid fibers, exclusively made by Dupont de Nemours, under the Kevlar brand (capability of 7000 tons); it is nearly total for carbon fibers, since the only national producer, Serofim (subsidiary of Rhone-Poulenc and Carbone-Lorraine, itself a PUK affiliate), makes only 10-15 tons/year. The situation is hardly brighter for matrix materials: CdF Chimie makes only 2000 tons of epoxy.

It is therefore not surprising to witness the major industrial maneuvers of recent months in an attempt to reduce this dependence.

French Dependence on Foreign Markets

An announced agreement between Elf-Aquitaine, Torray, and Union Carbide for a projected plant with a capability of 360 tons of carbon fiber per year, in the Sud-Ouest, was followed by the announcement of a PUK-Hercules agreement for a 200 tons/year plant, whose opening is scheduled for the end of 1983. In the crush, PUK established a composite materials division. Meanwhile, France is self-sufficient only for glass fibers. Our position is better in the field of advanced technology composites: carbon-carbon composites developed by SEP and Aerolor (subsidiary of Aerospatiale and Carbone-Lorraine); reinforced ceramic-matrix composites from SEP, which has also signed an agreement with Lafarge-Coppee for perfecting new high performance ceramic fibers; and boron-fiber based composites. Although there is practically no market in France, SNPE maintains a small fiber production unit at Bouchet, and is conducting an applications study (especially with aluminum matrices) in order to preserve an already significant technical know-how.

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NC MACHINE TOOLS IN NEW RENAULT FLEXIBLE WORKSHOP

Paris L'USINE NOUVELLE in French 25 Feb 82 pp 88-89

[Article by Patrick Piernax: "Digital Control Invades the Automobile"]

[Text] The investment that the Renault state-owned company has just allocated to modernization of the prototype components machine shop in the Billancourt plant amounts to close to 25 million francs. This decision finds expression in the massive arrival of digital control machines in Department 70. "We have deliberately aimed at digital control, in order to cope with the requirements for capacity, rapidity of execution and availability that are demanded at present of the prototype service," Bernard Hulot, director of central mechanical methods and forge of the state-owner company, stated. He went on to say: "For some years now, modifications of the mechanical components of automobiles have become more frequent (among others, in order to adapt to fuel economy). Moreover, we are witnessing the appearance of new components like the ones needed by diesel engines. Therefore, it was necessary to be capable of furnishing all the components included between the prototype and start of mass production in the shortest time possible."

Other objectives aimed at by the Billancourt plant are, on the one hand, to reduce the cost of components, which are generally high when they are produced by units, and, on the other hand, to limit recourse to subcontracting for reasons of confidentiality.

After 4 months of operation, the state-owned company believes that these objectives have been attained in part: "We are producing prototype cylinder blocks in a period of 2 months, compared with 3 months previously, and we expect to lower that period to 1 month shortly," Robert Riguidel, head of Department 70, stated. He added: "The cost of components manufactured in this new shop has been lowered by 15 to 25 percent for components formerly subcontracted and by 10 percent for our productions."

The new shop consists of two sections. One specializes in machining crankshafts; the other, more general, produces "prismatic" components: in fact, almost all the mechanical parts of a vehicle (cylinder blocks, cylinder heads, manifolds, water and oil pump covers, but also transmission housings, differential housings, without overlooking very different components like suspension arms and steering knuckles).

In order to meet these various requirements, the shop includes three four- and five-axle Graffenstaden CU 21 machining centers, with a storeroom for 60 tools and four Stama vertical drills. These seven machines are equipped with a digital control by means of Renault computers, of course! The shop is supplemented by an Ernault-Somua three-axle milling machine, a Mavilor vertical drill and a Tibo horizontal drill providing the capability of being able to drill 6-millimeter holes on 400 millimeter lengths. All these machines are proving to be capable of answering a variety of problems and of mass producing (from a few units to 500 components).

If taken one by one, these machines have nothing particularly original about them. Their simultaneous operation might have created management problems. The engineers in Department 70 were able to avoid this obstacle by investing from the start in a site for tool preparation and for assembling components. All the preadjustments and assemblage of components are performed in "masked" time. Moreover, the tools (several hundred) are arranged on two Industriever automatic vertical storage racks. What is just as remarkable is that presetting of tools is handled by a computer that puts out a perforated tape, consisting of the characteristics of all the tools set up in a machining center. "When a new component is initiated, the characteristics of the tools by digital control by computer are recorded instantaneously, thus avoiding shutting down the machine for 40 minutes to enter the data by hand," Jean-Marie Militon, assistant head of the department stated.

A Successful Operation Owing to the Training Program

The shop began operating in September 1981. As early as October, the shop was working at full capacity in two shifts (2 X 8). Jean-Marie Militon insisted on pointing out, however, that all the personnel had never worked on digital-controlled machines. He explained the success of the operation by the establishment of an interior training and recruiting program of all the personnel in the shop (a shop boss, two foremen and nine skilled workmen). The two foremen, recruited from shift foremen, received 1,000 hours of training (training in theory at ADEPA [Association for the Development of Automated Production] and practical training under a specialized subcontractor with the supplier of the machines). The operators (of the P3 level or chief technicians) benefited from 450 hours of theoretical and practical training, provided essentially by the central training department of Renault.

Very Valuable Flexibility of Use

This "training" department is going to be equipped shortly with a Graffenstaden CU 100 machining center, in order to handle Renault's increasing needs with regard to digital control. Installation of this shop is included in a general trend toward the use of digital control in the production of automobiles, even for mass production. "We firmly believe in its advantage in mass production machining," Bernard Hulot stated. In fact, although digital-controlled machines offer intrinsically a lower rate of productivity than chain conveyors, they provide a valuable flexibility of use for passing from one production batch to another or for small-scale production of variants of models for export.

Two examples illustrate this trend in the Renault group. In the Cleon plant, the surface of a clutch housing is now milled to shape by two milling machines driven on two axles by digital control (a solution that makes it possible to run the clutch and converter housing on the same position and it allows a new more compact design of the housing with a projecting part). Likewise, in the Mans plant, a machine consisting of two digital-controlled positions with three axles is soon going to replace a chain conveyor unit for producing two steering knuckles with identical hubs but different knuckles. "More generally, we are moving toward a considerable utilization of digital-controlled catalogue machines like machines for cutting gears, production milling machines and, of course, four-axle lathes," Bernard Hulot concluded.

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VSS: FIAT'S PLASTIC AUTOMOBILE PROJECT

Helsingborg PLASTFORUM SCANDINAVIA in Swedish no 1/2, 1982 pp 14-15

[Text] In issue 10 of PLASTFORUM last year we reported on Peugeot's project to manufacture an automobile containing as much plastic as possible, the so-called Project Vera. Fiat has also examined the possibility of creating such a car in a project called VSS, which stands for the Italian "Vettura Sperminetale a Sottosistemi."

This project is based on the Ritmo model, a car that already contains much plastic including the front and rear sections which are made of EPDM-modified polypropylene.

The results of this project are interesting but, as usual, it is impossible to produce such a car today, since the production process would be uneconomical and difficult from an organizational standpoint. The economic problems include primarily higher material costs and investments in new forms of production. The organizational difficulties result primarily from Fiat's system of subcontractors.

In general, Fiat's design is extremely simple. The automobile design has been divided into nonvisible supporting structures and visible nonsupporting structures. On this basis, an automobile has been designed with a steel "cage" on which external panels are then attached. Thus, the appearance of the automobile may be changed by quite simply by producing new panels. If only minor design changes are desired, the frame of the automobile may be kept unchanged. In this way, a number of different models may be made on the same frame. This means that the cost of tools and production costs for a frame may be spread over a greater number of finished automobiles and that the assembly time may be reduced by producing complete assembly systems that then may be attached to the frame. This term " assembly systems" appears constantly in this project. The goal is to achieve maximum integration with the fewest possible parts to assemble on the frame.

The VSS design is only an experiment with the body and the frame themselves. In the present stage, no attempt has been made to alter the mechanical or electrical systems.

What then has been achieved by this design? First of all, the plastic automobile is 21 percent lighter. The assembly time has been reduced by 5 hours compared to conventional methods and better noise insulation has been achieved. The design consists of nine different assembly systems that are mounted on the steel frame. The frame has also been simplified as much as possible and it is made of galvanized steel and HSLA steel plates.

From front to rear, the following parts are made of plastic:

Front

The front end is made as a unit consisting of a bumper, equipped with various assemblies, but mounted on tracks so that in a collision the entire bumper is pushed back so that the damage is as minor as possible. The front-end unit also contains a panel with the radiator grill, the air intake, and the headlights. Injection molding is used and the material is polycarbonate, which permits some deformation under stress.

Hood

The four elements that normally form the engine house--the hood itself, the internal supporting parts, and the left and right inner fenders--are combined into a single unit which also contains the ventilation system. The entire hood weighs about 12 kg, compared to about 17 kg for a comparable hood of steel. The hood is made of 3-mm glass fiber reinforced cellular polyester plastic.

Front Fenders

Since the hood overlaps the sides and the front end serves as part of the front fenders, the traditional front fenders consist only of small connection sections between the front wheels and the doors. They are made of 2.5-mm SMC and are bolted to the frame in the final stages of assembly.

Front and Back Doors

Each door consists of two plates made of SMC. The plates are joined at the edges and have a supporting brace of HSLA steel inside. The brace acts as both collision protection and a support for the window mechanism, the hinges, and the lock.

Rear Unit

The rear section of the automobile consists of several plastic panels that are joined together "off-line" and then mounted to the frame as a unit. The floor and sides of the luggage compartment and the back cross member and bumper are two separate moldings of polycarbonate. The back fenders are made of SMC.

Hatchback

The hatchback is a single plate of 2.5-mm SMC which is made stable by installing

the back window.

Roof

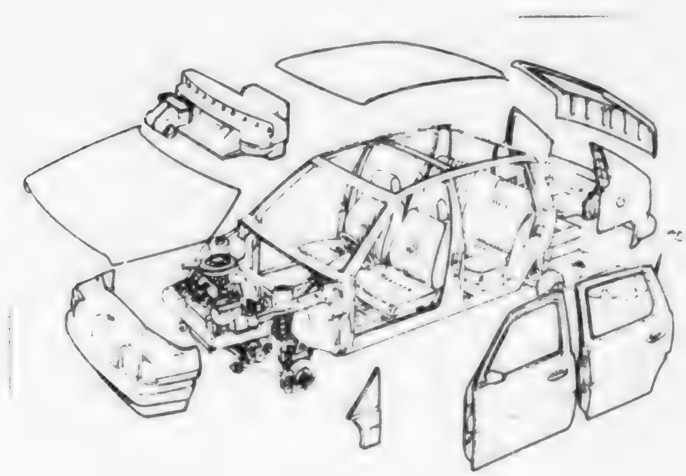
The roof is made of 3-mm cellular polyester plastic.

Instrument Panel

Two individual component systems form the instrument panel. One system includes the heater, air vent, and space for the spare tire, among other things. All this is in one component. This section is completely independent of the inner dashboard which contains instruments, controls, and the steering.

This design means that the ventilation unit provides sufficient insulation from noise and heat from the engine house. Thus, no insulation mats are needed.

This instrument panel design makes it possible to have variations in a single automobile model and instruments and controls may be given a new design without changing the entire appearance of the dashboard. In addition to these parts, like most European cars, this automobile has a fuel tank of polyethylene.

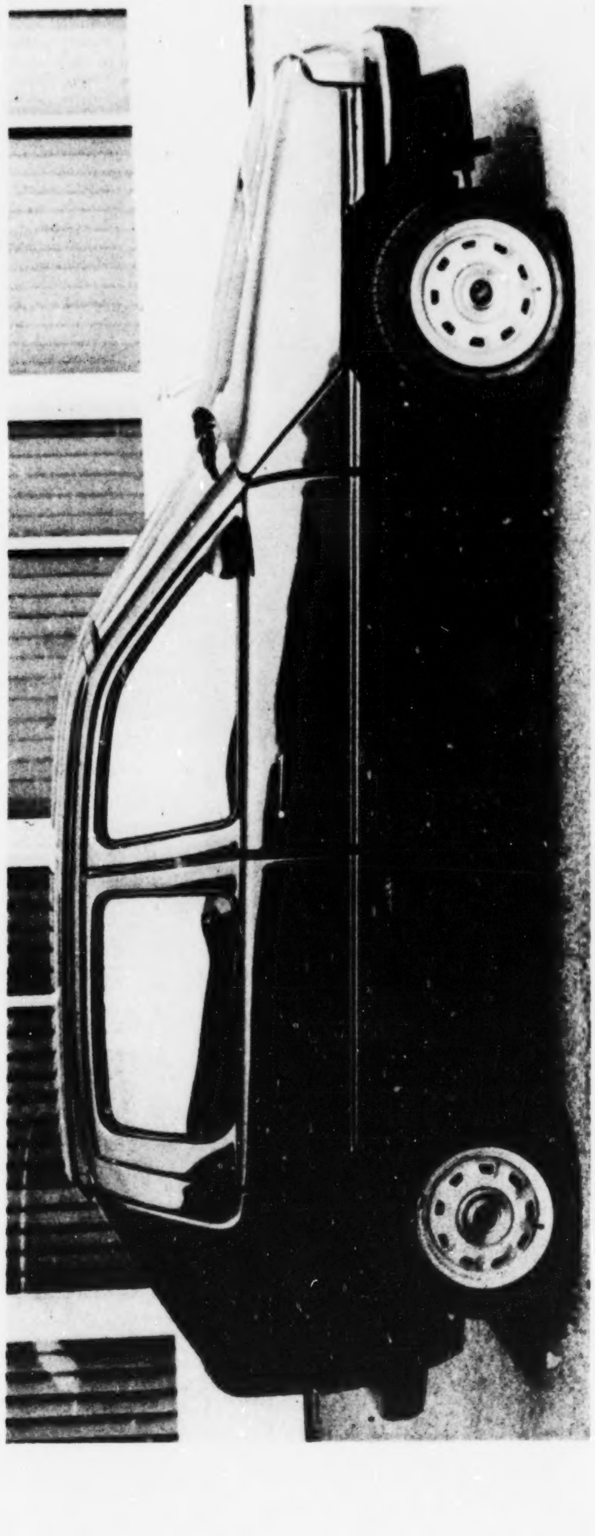


These parts in Fiat's experimental car are made of plastic.

Ritmo and VSS: Table of Comparative Weights

	Ritmo kg	VSS kg	kg	%
Nonmoving body parts	197.20	159.10	-38.10	-19.3
Front doors complete with inner panels	43.66	29.80	-13.86	-31.8
Back doors complete with inner panels	36.46	29.80	- 6.66	-18.3
Hatchback	19.10	15.30	- 3.80	-19.9
Hood	17.10	12.10	- 5.00	-29.2
Instrument panel	4.80	4.40	- 0.40	- 8.3
Total body weight	318.32	250.50	-68.42	-21.3

Component system	Unsaturated SMC polyester	Cellular polyester plastic	Poly-carbonate	Modified PPO	High-molecular polyethylene
Front panel			X		
Front bumper			X		
External fenders	X				
Floor of luggage compartment			X		
Internal fenders			X		
Rear parts			X		
Rear bumper			X		
Hood		X			
Hatchback	X				
Back doors	X				
Front doors	X				
Roof		X			
Instrument panel				X	
Fuel tank					X



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TRANSPORTATION

BRIEFS

NEW TIRES SAVE FUEL--Frankfurt, 10 February--Scientists at Dunlop in Birmingham have developed, according to a report in the magazine "Industrial Research and Development (number 12/1981, p 80), a new type of automobile tire which reduces fuel consumption by up to 5 percent. In the opinion of a leading Dunlop manager, this can be considered the greatest step forward in tire technology in the last 40 years. As is well known, fuel consumption can be reduced by lowering the roll resistance of the tire on the road. According to the report, Dunlop scientists appear to have accomplished this without degrading braking power by using a new type of polymer. The director of the tire test laboratory at Dunlop, Geofrey Morton, said in this connection that the problem was to discover a material which absorbs less energy while rolling but which absorbs more when skidding. The idea was that the problem could be solved by a mixture of materials which individually need not be at all suitable for the road-contact surfaces of tires. According to the test results reported by Dunlop, the fuel consumption of a 1.3 liter Austin Metro equipped with the new tires was reduced by 5.2 percent. [Text] [Frankfurt/Main FRANKFURTER ZEITUNG/BLICK DURCH DIE WIRTSCHAFT in German 11 Feb 82 p 7] 9160

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April 26, 1982